Claims

What is claimed is:

1. A microturbine engine comprising:

a compressor creating a flow of compressed air;

a recuperator preheating the flow of compressed air;

a combustor section mixing the preheated compressed air with a fuel and combusting the mixture to create a flow of products of combustion;

a radial flow turbine having turbine blades and supported for rotation about a longitudinal axis;

a turbine shroud surrounding the turbine;

a scroll case surrounding the turbine shroud;

a support member;

an inlet defined between the support member and the turbine shroud and communicating between the inside of the scroll case and the inside of the turbine shroud;

a plurality of inlet guide vanes in the inlet and adapted to direct fluid flow to impinge upon the turbine blades;

a plurality of resilient members;

a plurality of bolts each having a bolt head and each extending through the turbine shroud, one of the guide vanes, the support member, and one of the resilient members; and

a nut threaded onto each bolt to trap the turbine shroud, guide vanes, support member, and resilient member in a gap defined between the nut and the bolt head;

wherein the products of combustion enter the scroll case in a direction substantially perpendicular to the longitudinal axis of the turbine;

wherein the products of combustion enter the inlet, cause the turbine to rotate, and exit the turbine shroud as a flow of exhaust gas in a direction generally parallel with the longitudinal axis of the turbine;

wherein the guide vanes, turbine, and turbine shroud expand in response to being heated by the products of combustion;

wherein the resilient members deflect to at least partially accommodate such thermal expansion; and

wherein the flow of exhaust gas flows through the recuperator to preheat the compressed air.

2. The engine of claim 1, wherein the resilient member includes a compression spring around the bolt and between the nut and the support member.

3. The engine of claim 1, wherein the resilient member includes a plurality of Bellville washers around the bolt and between the nut and the support member.

4. The engine of claim 1, wherein the nut is tightened on the bolt to preload the resilient member with a compressive force and to preload the bolt with a tensile force.

5. The engine of claim 1, wherein during ordinary operation of the engine the resilient member accommodates sufficient thermal expansion to prevent the bolt from reaching its elastic limit.

6. The engine of claim 1, wherein the bolts are arranged in a generally circular pattern substantially centered about the longitudinal axis of the turbine.

7. The engine of claim 6, wherein the turbine shroud includes a generally conical section having a longitudinal axis substantially colinear with the turbine longitudinal axis, and a lip extending generally perpendicular to the longitudinal axis and defining a ring through which the bolts pass generally parallel to the longitudinal axis.

8. The engine of claim 1, further comprising an antirotation interface between each inlet guide vane and the support member to resist rotation of the inlet guide vane about the bolt.

9. The engine of claim 8, wherein the antirotation interface includes a protrusion on the each inlet guide vane and a recess in the support member into which each protrusion is received.

10. A radial flow turbine comprising:

a rotor including a plurality of vanes defining an inlet, an outlet, and a flow path therebetween;

a shroud positioned to cover at least a portion of the flow path;

a housing positioned to at least partially support the rotor for rotation about a rotational axis, the housing at least partially defining a chamber for the receipt of a flow of products of combustion; and

a plurality of nozzle guide vane assemblies positioned to provide fluid communication between the chamber and the inlet, each of the plurality of nozzle guide vane assemblies positioned adjacent another nozzle guide vane assembly to at least partially define one of a plurality of converging flow paths, each nozzle guide vane assembly including:

a guide vane positioned between the shroud and the housing and including an aperture therethrough;

a bolt engaged with the shroud and extending through the aperture to sandwich the guide vane between the shroud and the housing; and

a resilient member having a stiffness less than the bolt and cooperating with the bolt to apply a compressive force to the guide vane.

11. The radial flow turbine of claim 10, wherein the shroud includes an inlet portion that is substantially perpendicular to the rotational axis, the inlet portion adapted to engage the guide vanes.

12. The radial flow turbine of claim 10, wherein the housing includes a support member and a scroll, the support member, the scroll, and the shroud cooperating to at least partially define the chamber.

13. The radial flow turbine of claim 10, wherein the guide vanes are sandwiched between the support member and the shroud.

14. The radial flow turbine of claim 10, wherein the bolt includes a first dowel portion and a second dowel portion and wherein the first dowel portion sized to engage the guide vane and the housing and the second dowel portion sized to engage the guide vane and the shroud to position the guide vane.

15. The radial flow turbine of claim 10, wherein the resilient member includes a spring.

16. The radial flow turbine of claim 10, wherein the resilient member includes a plurality of Bellville washers arranged to define a spring.

17. The radial flow turbine of claim 10, wherein the resilient member is disposed between a nut threaded to the end of the bolt and the housing, and wherein the bolt compresses the resilient member to apply the compressive force to the guide vane.

18. A method of assembling a radial flow turbine to accommodating differential thermal growth of a nozzle guide vane of the radial flow turbine, the method comprising:

supporting a turbine rotor in a turbine housing for rotation about a rotational axis, the turbine rotor defining an inlet, an outlet, and a flow path therebetween;

positioning a shroud adjacent the flow path, the shroud cooperating with the housing to at least partially define a chamber for the receipt of a flow of products of combustion;

arranging a plurality of nozzle guide vanes to define a plurality of converging flow paths to provide fluid communication between the chamber and the inlet;

tensioning a plurality of bolts, each bolt corresponding with one of the nozzle guide vanes to sandwich each of the plurality of nozzle guide vanes between the shroud and the housing; and

positioning a plurality of resilient members, each resilient member corresponding with one of the bolts such that each of the plurality of bolts compresses the corresponding resilient member and the resilient member applies a compressive force to the corresponding nozzle guide vane.

19. The method of claim 18, wherein the positioning step further comprises arranging a plurality of Bellville washers on the bolt to at least partially define the resilient member.

20. The method of claim 18, further comprising heating the guide vanes with the flow of products of combustion such that the guide vanes thermally expand, and further compressing the resilient member in response to the thermal expansion of the guide vanes.